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SLACKWATER DARTER RECOVERY PLAN

RECOVERY PLAN FOR THE SLACKWATER DARTER, *ETHEOSTOMA BOSCHUNGI*

Prepared by

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For the

U.S. Fish and Wildlife Service

Atlanta, Georgia

Approved: 

James W. Pulliam, Jr.
Regional Director, Southeast Region

Date: March 8, 1984

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LITERATURE CITATIONS SHOULD READ AS FOLLOWS:

U.S. Fish and Wildlife Service. 1984. Slackwater Darter Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 45 pp.

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TABLE OF CONTENTS

PREFACE

The following are the only publications in widely distributed literature concerning Etheostoma boschungi: the original description of Wall and Williams (1974); a paper by Ultsch et al. (1978) on metabolism, critical oxygen tension, and habitat selection; the subgenus Ozarka by Williams and Robison (1980); an account of the species in the Atlas of North American Freshwater Fishes by Boschung (1980 et seq.); and an abstract by Boschung (1979) on life history notes. Other papers have resulted from proposals to recognize the slackwater darter as threatened or endangered in Alabama (Ramsey, 1976), in Tennessee (Starnes and Etnier, 1980), and nationally (Deacon et al., 1979). For the most part, the data in the Introduction is from reports by Boschung (1976 and 1979) to the United States Department of Agriculture, Soil Conservation Service. These reports have limited distribution in the scientific community. Some details not repeated in this Recovery Plan may be found in the SCS reports, except that on food habits which was compiled by David Nieland (1981) from specimens in The University of Alabama Ichthyological Collection.

PART I: INTRODUCTION

Background

On September 9, 1977, the U.S. Fish and Wildlife Service published in the Federal Register a final rulemaking indicating its determination that the slackwater darter (Etheostoma boschungi) is a threatened species, under the Endangered Species Act of 1973, as amended. Critical habitat was designated when the species was listed.

The slackwater darter was described by Wall and Williams (1974) from a series of specimens collected in Cypress Creek, Lauderdale County, Alabama; Flint River, Madison County, Alabama; and Buffalo River, Lawrence County, Tennessee. The holotype, Tulane University (TU) 79424, is an adult male, 50.7 mm standard length, collected in Lindsey Creek near Central Highlands, Lauderdale County, Alabama (T1S, R12W, Sec. 3) by Charles Gooch and James D. Williams on 22 November 1969. Twelve paratypes were collected with the holotype and deposited in TU 79425 and The University of Alabama Ichthyological Collection (UAIC) 3774. Other paratypes are deposited in TU, UAIC, U.S. National Museum, University of Michigan Museum of Zoology, University of Kansas, University of Florida (Florida State Museum), University of Tulsa Museum, University of Tennessee, Mississippi State University, and Florida State University (subsequently transferred to Florida State Museum).

Etheostoma boschungi was placed in the subgenus Oligocephalus until recently when Williams and Robison (1980) described a new subgenus, Ozarka, to contain with E. boschungi, E. punctulatum, E. cragini, E. pallididorsum, and E. trisella. Ozarka are medium-sized darters, ranging from 40 to 70 mm standard length, that typically inhabit gentle riffles and slackwater areas of small to medium-size shallow, upland tributary streams (Williams and Robison, 1980).

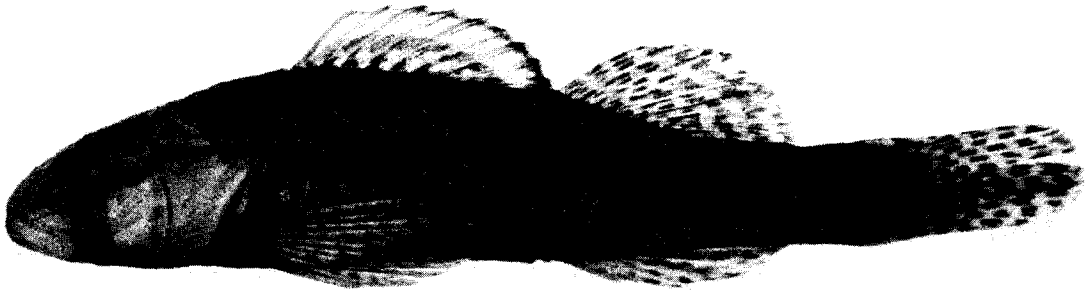


Figure 1. Etheostoma boschungi, new species. Paratype, UAIC 3973, adult male, 46.9 mm SL, from Copeland Branch, tributary to Briar Fork of Flint River, Madison Co., Alabama, 24 October 1970 (from Wall and Williams, 1974).

Diagnosis

The slackwater darter (Fig. 1) differs from other Ozarka in having the following combination of characters: Two anal spines; lateral line with 45 to 58 scales, 34 to 38 of which are pored; soft dorsal fin usually with 11 or 12 rays; a bold blue-black subocular bar; three prominent dorsal saddles; and 35 to 37 vertebrae (Wall and Williams, 1974; Williams and Robison, 1980). In the field, specimens in the water can be readily identified by the three prominent saddles and wide subocular bar. The distribution of the species of Ozarka is seen in Fig. 2.

Distribution

The slackwater darter is known from the following five tributary streams to the south bend of the Tennessee River:

1. Buffalo River, Lawrence County, Tennessee (South Fork, 9.9 mi N of Lawrenceburg at U.S. Hwy 43 and upstream; Chief Creek at TN Hwy 20, about midway between Henryville and Center);

2. Shoal Creek, Lawrence County, Tennessee, near Lawrenceburg, 1 specimen (personal communication, Lawrence Page);

3. Flint River, Madison County, Alabama (Copeland Branch on West Limestone Road; West Fork at U.S. Hwy 431; Briar Fork at U.S. Hwy 431);

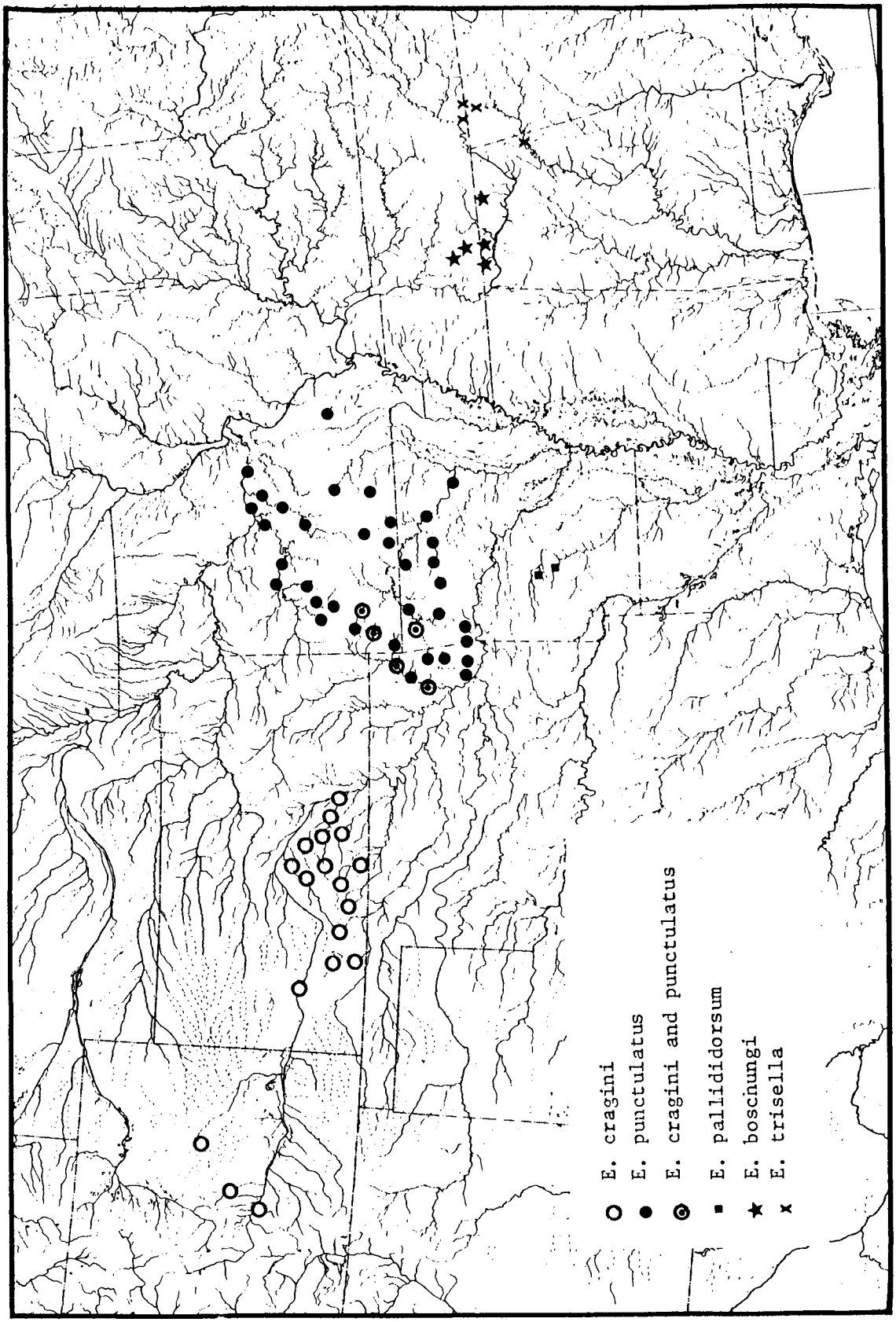


Figure 2. Distribution of Ozarka

4. Swan Creek, near Athens, Limestone County, Alabama; and

5. Cypress Creek Watershed, exclusive of Little Cypress Creek, Wayne County, Tennessee and Lauderdale County, Alabama (Burcham Creek, Lindsey Creek, North Fork, Dulin Branch, unnamed tributary to Main Cypress Creek near Cypress Inn, Greenbrier Branch, and Middle Cypress Creek (Figs. 3 and 4)).

Hundreds, perhaps thousands, of fish collections have been made in this century in the south bend of the Tennessee River by ichthyologists, fish biologists, and survey teams from universities and various Federal and State agencies. To this date, only those localities shown in Fig. 3 have yielded specimens of the slackwater darter.

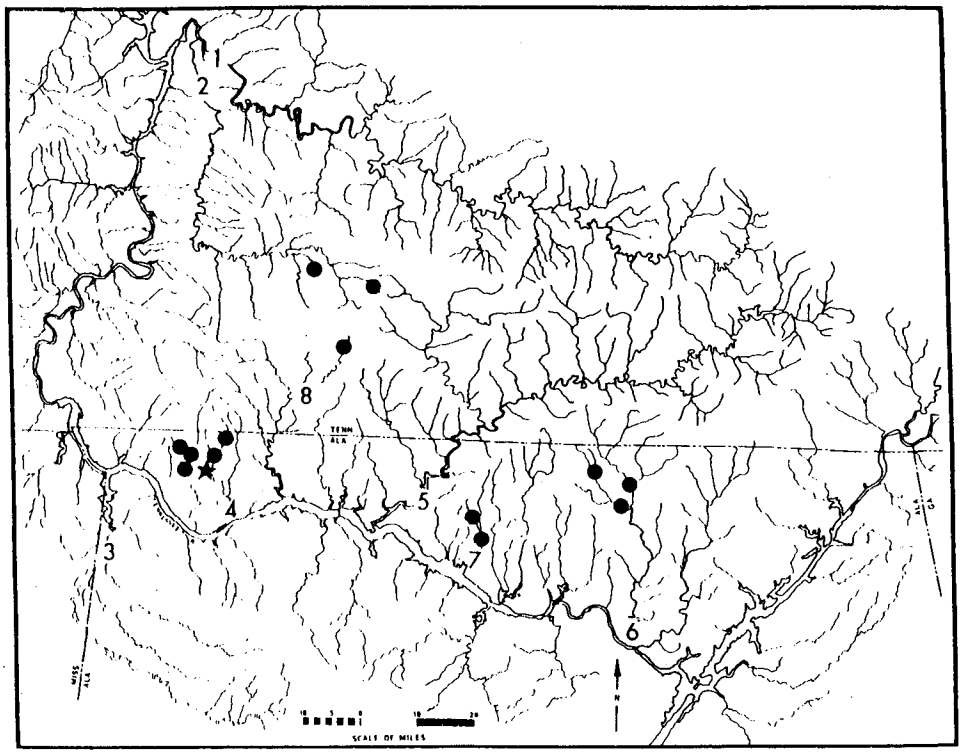


Figure 3. Distribution of E. boschungi. Star represents the type locality. Selected tributary systems of the Tennessee River are numbered: 1 Duck; 2 Buffalo; 3 Bear Creek; 4 Cypress Creek; 5 Elk River; 6 Flint River; 7 Swan Creek; 8 Shoal Creek.

Physiographically, the area occupied by the slackwater darter is the Highland Rim of the Nashville Basin. Congeners, more or less limited to this area, are: Etheostoma blennius, E. cinereum, E. duryi, E. rifilineatum, and E. tuscumbia.

With the exception of Flint River and Swan Creek, present-day distribution of slackwater darters is in those headwater streams arising from the highlands of Lawrence and Wayne counties, Tennessee. The darter is not known from the Elk River, the largest tributary in the south bend of the Tennessee River. However, the Elk interposes the Buffalo and Flint rivers, two streams where slackwater darters are found. They are also absent from Bear Creek, the largest north-flowing tributary.

Origin

Genetically, E. boschungi may be derived from parental Ozarkian stock from Arkansas and Missouri, and probably differentiated as an eastern species following some geologic event, such as the Mississippi embayment, that led to their isolation. The five disjunct populations are probably remnants of a past continuous and more ubiquitous distribution. Speculations on possible causes of the reduction in geographic distribution of the species are discussed below in the section on threats.

Geographic Variation

Gene flow between the disjunct populations of E. boschungi is highly unlikely in that the adult darters would have to migrate great distances and traverse the Tennessee River impoundments. Nevertheless, the disjunct populations show no evidence that they have diverged into unique groups (Wall and Williams, 1974).

Habitat

The slackwater darter occurs in two distinctly different, but necessarily adjacent, habitats: nonbreeding habitat and breeding habitat. The breeding habitat must be accessible via a suitable nonbreeding habitat.

Nonbreeding habitat. The slackwater darter's nonbreeding habitat is small (60 cm wide and 15 cm deep) to moderately large (12 m wide and up to 2 m deep) streams. The current is usually slow, and under normal conditions, the flow ranges from still to 0.34 m/sec. In small streams, the darters show no position preference; however, in large streams, such as Lindsey Creek, they seem to confine themselves to near the banks or to undercuts in the banks. They also occur on gravel infiltrated with silt, on silt and mud, or in a combination of these. They have not been observed over clean gravel in swift streams, or in swift rocky areas. Slackwater darters show some preference for accumulations of detritus, such as small twigs and

well-decayed leaves, but not large concentrations of new-fallen compacted leaves. Their movement is not impeded by moderate riffles or by shallow water. Oxygen is not a factor in limiting their habitat as they are tolerant of rather low oxygen levels; however, they do inhabit water in the summer that would be uninhabitable without a downward shift in critical oxygen tension (Ultsch et al., 1978). The physical nature of the stream is probably the limiting factor in respect to slackwater darter distribution.

Breeding Habitat. The breeding habitat of the slackwater darter is seepage water in open fields and woods. The fish have not been found in swamps or overflow pools of standing water. The locations and characteristics of the known breeding sites, all in Cypress Creek Watershed, are seen in Fig. 4 and Table 1 respectively. The unifying characteristic of breeding sites is the presence of seepage water. The water in the breeding place is usually about 4 to 8 cm deep and it flows slowly into an adjacent stream. Typically the breeding site is 30 to 45 cm above the adjacent stream; therefore, the stream water must periodically rise (as it does during heavy rains) to give the ready-to-spawn darters access to the breeding grounds.

Essential Habitat. Both the nonbreeding and breeding habitats as described above are indispensable for sustaining populations of slackwater darters. The two distinctly different habitats must be adjacent; that is, the fish must be able to swim from stream to spawning area and vice versa. The limiting factor relative to reproductive success is the breeding habitat.

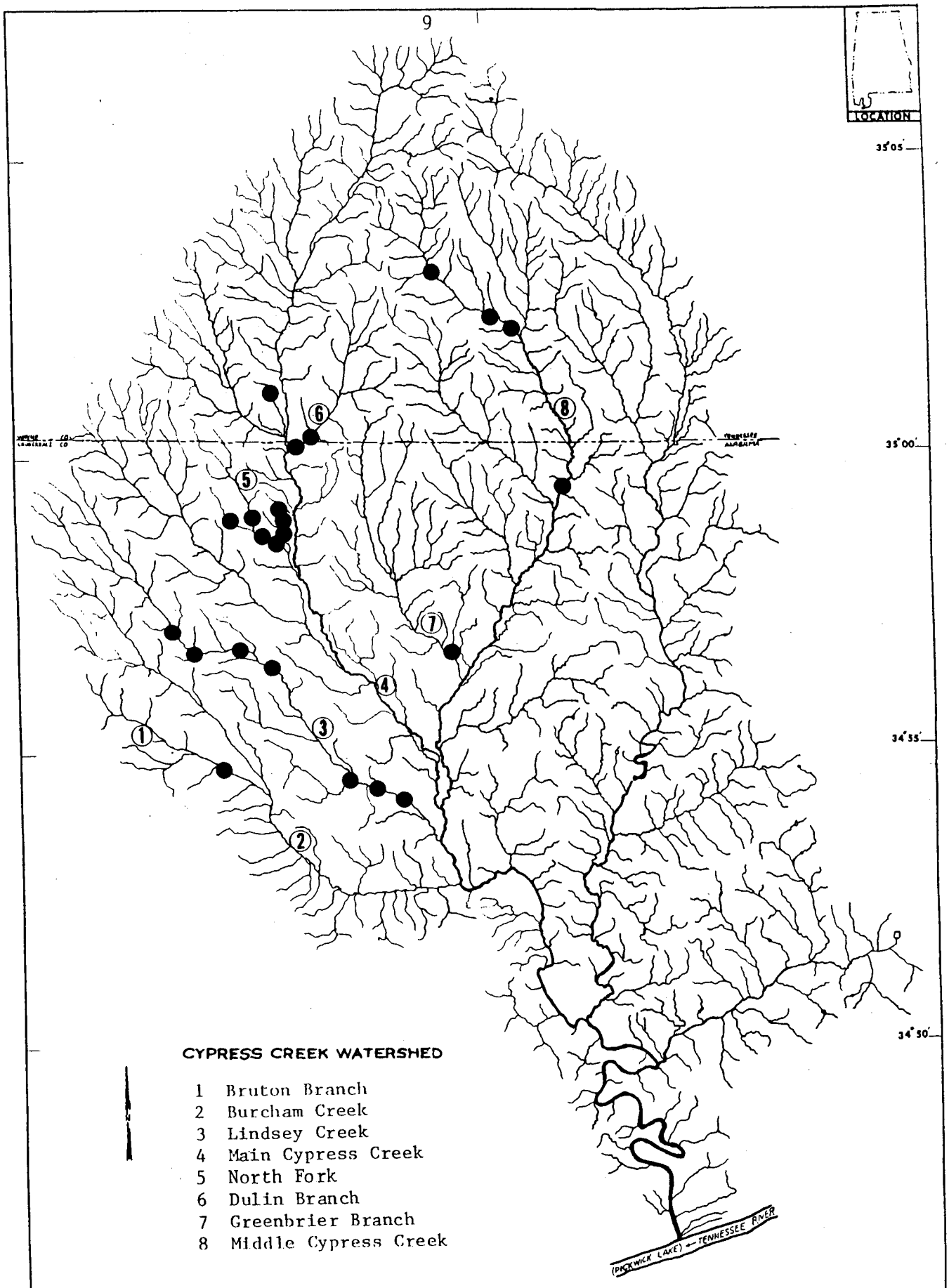


Fig. 4 Dots represent localities of E. boschungi.

Table 1. Characteristics of the breeding sites of the slackwater darter.

Site Name	Location	Elevation	Soil Type	Water Source	Vegetation
Miles	Elijah Branch, trib. to North Fork, map 1*	ca 680'	Lee cherty silt loam	Wet weather seepage	Open pasture, Juncus, Eleocharis
Joseph Austin	Off North Fork, map 1	ca 655'	Lee and Lobelville cherty loam	Wet weather seepage	Semiwooded, partly open, sparse sweetgum and beech; Panicum and Festuca
Douglas Austin	Trib. to Cypress Creek, map 1		Staffell and Bodine, Etowah silt loam, Lee cherty silt loam	Wet weather seepage and spring	Wooded, partly open; mixed hardwoods, Festuca
"Z"	Off Lindsey Creek, map 2	ca 695'	Lobelville cherty silt loam	Wet weather seepage	Wooded; sweetgum and red maple
County 5 (Natchez Trace)	Off Lindsey Creek, map 2	ca 620'	Lee cherty silt loam	Wet weather seepage	Wooded; river birch, alder, sweetgum, willow, Eleocharis, Fontinalis
Natchez Trace Parkway	Trib. to Cypress Creek approx. ½ mi NW Cypress Inn, TN, map 3	ca 690'	?	Wet weather seepage	Open pasture; Juncus, Eleocharis and Festuca
Dodd 1	Middle Cypress Creek, Cypress Inn Quad., TN, map 4	ca 830'	?	Spring and seepage	Open pasture; Juncus, Eleocharis and Ranunculus
Dodd 2	Middle Cypress Creek, Cypress Inn Quad., TN, map 4	ca 840'	?	Spring and wet weather seepage	Open pasture; Juncus and Callitriche

*Maps are Appendix A.

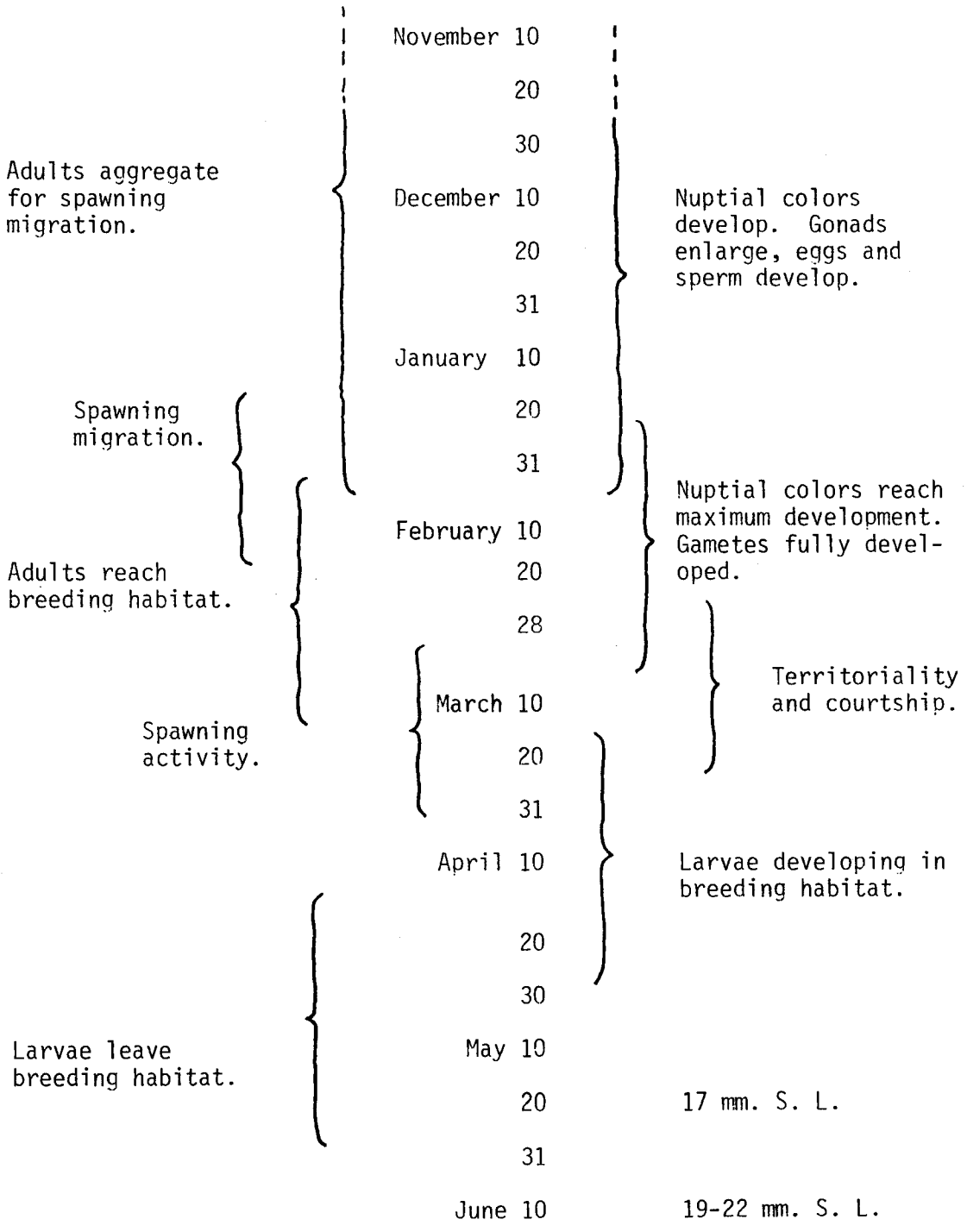
Undoubtedly the declining ground water table has adversely affected the number of breeding sites and has therefore limited the geographical distribution of the darter.

Life History Aspects

Reproduction. The sequence of events in the reproductive strategy of the slackwater darter is seen in Table 2. The chronology of events undoubtedly varies from year to year, depending upon temperature and rainfall. Rainfall must be heavy enough to cause flooding that will "lift" the adults into the spawning grounds; and, there is no evidence of spawning in water less than 14 degrees C. The act of spawning has not been observed; however, a male was observed "guarding" a clump of Juncus. His behavior was aggressive, attacking a straw probe when placed near him. The fish would not leave voluntarily; if chased away, he would return immediately and swim around and into the Juncus. Several days after this observation, eggs were found in the Juncus and they were laid either singularly or in two's or three's (Figure 5) (personal observation).

Fecundity. Several estimates were made of the number of eggs produced per female. Three specimens averaged 320 ripe eggs; however, another had approximately 1000 eggs in some stage of development. Based on a cursory inspection of swimming larvae, the annual replacement potential is impressive.

Table 2. The sequence of events in the reproductive strategy of Etheostoma boschungi as observed in 1975-76 (Boschung, 1976).



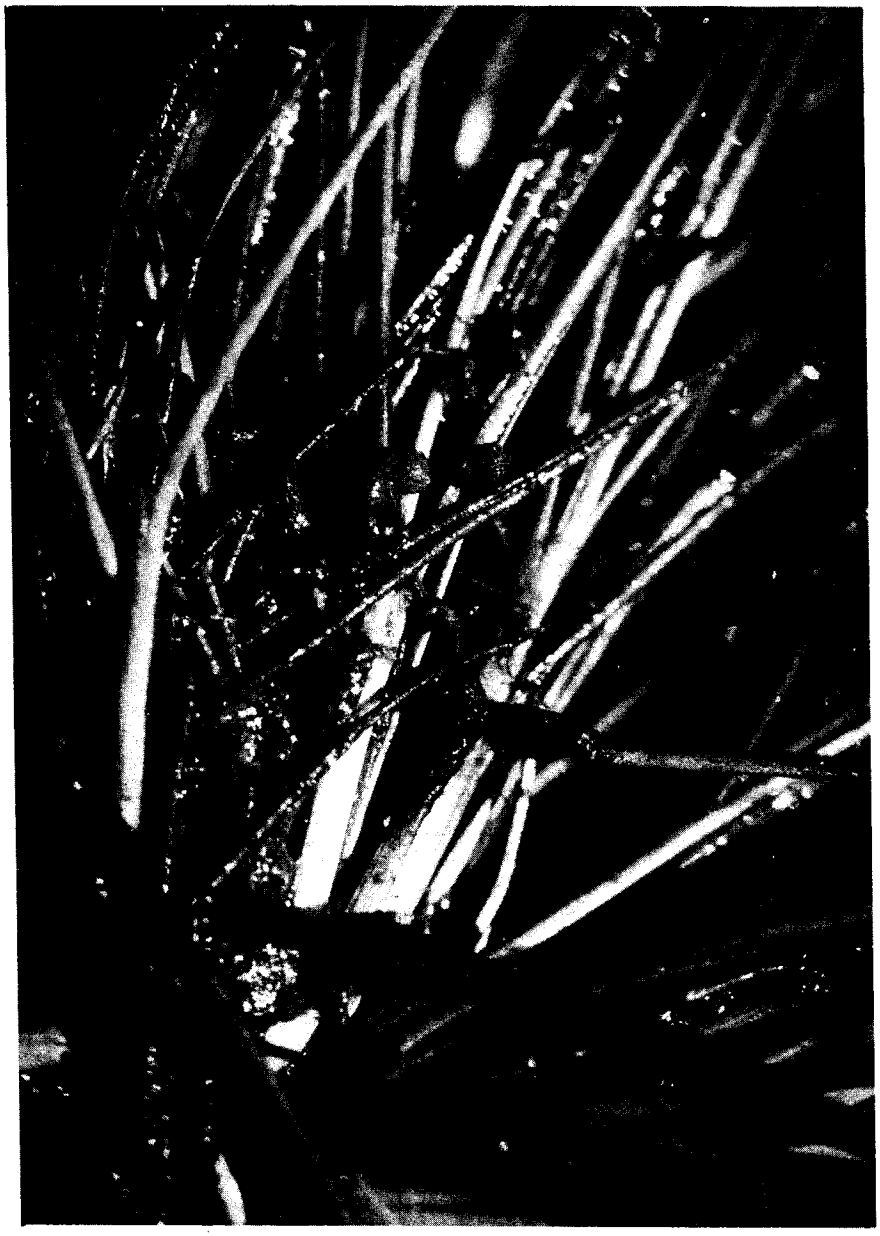


Fig. 5. Eggs of E. boschungi attached to Juncus.

Growth. Fig. 6 gives us some idea of growth rates. The initial growth period is rather rapid. Specimens in early April are from 10 to 12 mm S.L., and by early June they have doubled in length. By the end of the first year they are, for the most part, 30 mm ± 2 mm S.L. Year-round length-frequency data are not available, but it appears that most specimens collected at any given time are in either the 1- or 2-year class. There is evidence that few, if any, live more than three years. If this is true, two consecutive unsuccessful reproduction seasons would virtually eliminate a population.

Food. Nieland (1981) examined the stomachs of 80 specimens 25 mm or greater S.L. Thirty were from the breeding habitat, the remainder from various streams in the Cypress Creek watershed. A summary of his data is shown in Table 3. Nieland quantified the degree of comparison or contrast between diets of slackwater darters occupying each habitat. The overlay value (using Pianka's, 1973, equation where zero indicates no overlap and one indicates complete overlap) was 0.135, indicating little similarity in diets. It is obvious that the darter can make a shift in diet concomitant with the shift in habitat.

Species Associates. Forty species in 12 families of fishes are known to occur with Etheostoma boschungi (Table 4). Those species most often found with slackwater darters are (in order of percent occurrence): Clinostomus funduloides, Etheostoma cf. squamiceps, Campostoma anomalum, Etheostoma

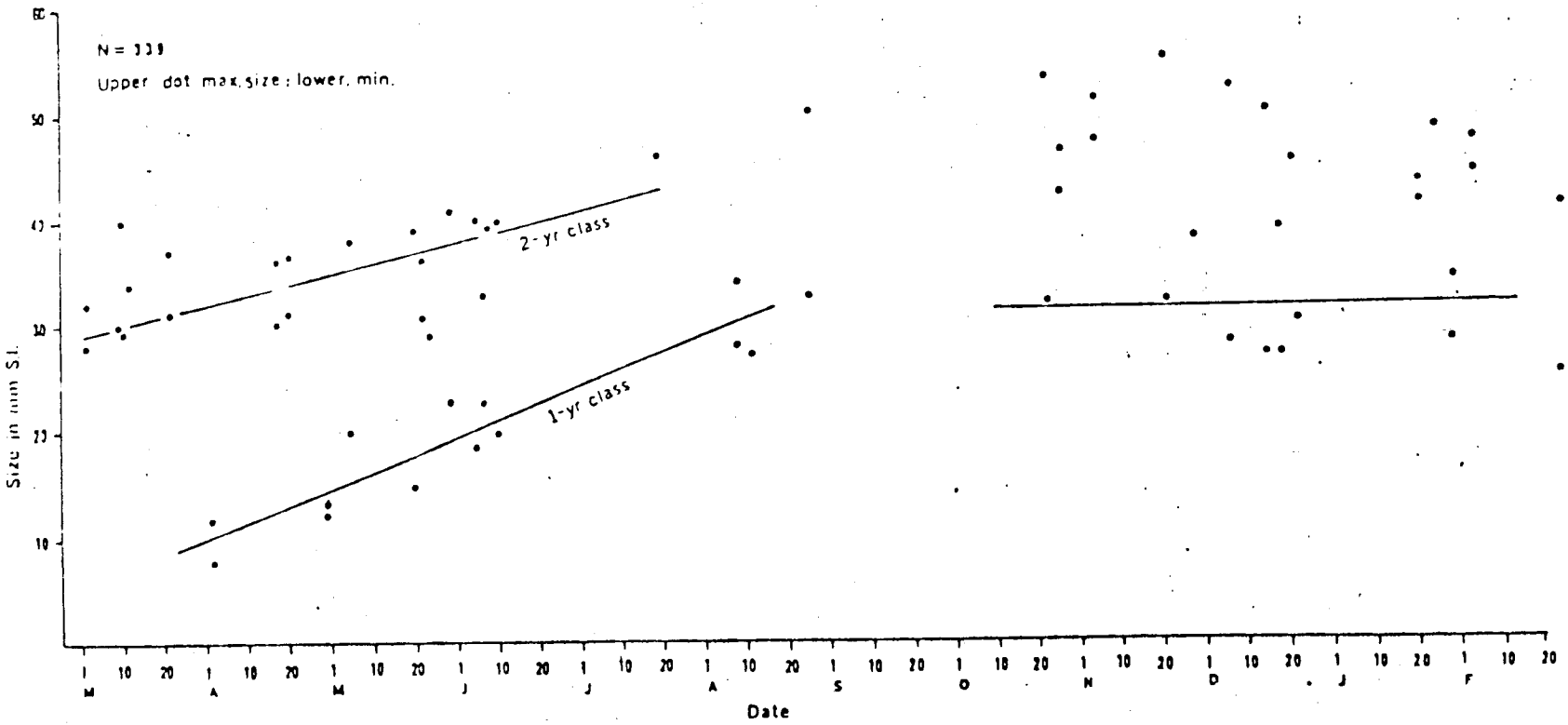


Fig. 6 Distribution of minimum and maximum sizes of Etheostoma boschungi by 10-day intervals.

Table 3. Stomach contents of E. boschungi from Cypress Creek Watershed (Nieland, 1981).

	E. boschungi					
	Creek Habitat N=50		Breeding Habitat N=30		Total N=80	
Food Organism	No.	% occurrence	No.	% occurrence	No.	% occurrence
Crustacea						
Ostracoda	--	--	2	1.06	2	.86
Copepoda	--	--	102	54.54	102	43.97
Isopoda	--	--	9	4.81	9	3.88
Amphipoda	--	--	45	24.06	45	19.40
Decapoda	3	6.67	--	--	3	1.29
Insecta						
Ephemoptera	31	68.89	13	6.95	44	18.97
Trichoptera	4	8.89	--	--	4	1.72
Coleoptera	1	2.22	2	1.07	3	1.29
Diptere	6	13.33	14	7.49	20	8.62
Total	45	100.00	187	100.00	232	100.00

Table 4. List of fish species known to occur with *Etheostoma boschungi*. [1]

Common Name	Scientific Name
Southern brook lamprey	Ichthyomyzon gagei
Least brook lamprey	Lampetra aepyptra
Grass pickerel	Esox americanus
Chain pickerel	Esox niger
Stoneroller	Campostoma anomalum
Rosyside dace	Clinostomus funduloides
Flame chub	Hemitremia flammea [2]
River chub	Nocomis micropogon
Rosefin shiner	Notropis ardens
Striped shiner	Notropis chrysocephalus
Warpaint shiner	Notropis coccogenis
Ribbon shiner	Notropis fumeus
Telescope shiner	Notropis telescopus
Southern redbelly dace	Phoxinus erythrogaster
Bluntnose minnow	Pimephales notatus
Blacknose dace	Rhinichthys atratulus
Creek chub	Semotilus atromaculatus
White sucker	Catostomus commersoni
Creek chubsucker	Erimyson oblongus
Northern hog sucker	Hypentelium nigricans
Black redhorse	Moxostoma duquesnei
Golden redhorse	Moxostoma erythurum
Yellow bullhead	Ictalurus natalis
Pirate perch	Aphredoderus sayanus
Northern studfish	Fundulus catenatus
Blackspotted topminnow	Fundulus olivaceus
Mosquitofish	Gambusia affinis
Rock bass	Amblophites rupestris
Green sunfish	Lepomis cyanellus
Bluegill	Lepomis macrochirus
Longear sunfish	Lepomis megalotis
Smallmouth bass	Micropterus dolomuei
Spotted bass	Micropterus punctulatus
Largemouth bass	Micropterus salmoides
Rainbow darter	Etheostoma caeruleum
Blackside snubnose darter	Etheostoma duryi
Fantail darter	Etheostoma flabellare
Tennessee snubnose darter	Etheostoma simoterum
Spottail darter	Etheostoma cf squamiceps [2]
Banded sculpin	Cottus carolinae

1 Source: Wall and Williams, 1974; Boschung, 1976.
2 Occur with *E. boschungi* in breeding habitat.

flabellare, E. duryi, Hypentelium nigricans, and Fundulus olivaceus. As expected, those least associated are the larger stream genera such as Moxostoma and Micropterus.

Predators. Only two fish species are definitely known to feed on slackwater darters as based on stomach contents; that is, Lepomis cyanellus and Aphredoderus sayanus.

Conservation

Critical habitat. As mentioned earlier, an official critical habitat designation has been made for this species. This critical habitat designation is in Lauderdale County, Alabama, and Wayne and Lawrence Counties, Tennessee. In Lauderdale County, Alabama, it includes all permanent and intermittent streams with flowing water from December to June which are tributary to Cypress Creek and its tributaries upstream from the junction of Burcham Creek, including Burcham Creek, excluding Threet Creek and its tributaries. In Wayne County, Tennessee, it includes all permanent and intermittent streams with flowing water from December to June which are tributary to Cypress and Middle Cypress Creek drainage. In Lawrence County, Tennessee, it includes the Buffalo River and its tributaries.

Population size. Each of the isolated populations of slackwater darters outside Cypress Creek Watershed is very small in size and apparently suitable habitats are minimal (personal observation). The streams and the number of specimens collected from them are:

Locality	# specimens	approx. man-days effort
Buffalo River: South Fork	18	45
Chief Creek	2	10
Flint River: West Fork	4	30
Briar Fork	1	30
Copeland Branch	21*	30
Swan Creek: above Athens	3	?
below Athens	5	?
Shoal Creek: near Lawrenceberg	1	?
Cypress Creek: throughout	200**	numerous

* 20 additional specimens released
** numerous specimens released

It is, of course, possible that slackwater darters occur in other streams. The specimens from Shoal and Swan creeks were collected since the 1976 SCS report. Often it is a matter of being at the right place at the right time. On 9-10 March 1976, 12 man-hours collecting yielded only three specimens in South Fork, Buffalo River. Numerous attempts in Flint River have failed to yield additional specimens. This is not the case in Cypress Creek. The Cypress Creek Watershed, exclusive of Little Cypress Creek, is the stronghold for slackwater darters.

An attempt was made in December 1975 to estimate the population size in Cemetery Branch, a tributary to North Fork. Cemetery Branch is near three known breeding sites. By mark and recapture in a 27 m long section of the stream, it was estimated that the population numbered between 103 and 195. The darter is gregarious. In this case the group was assembled in a relatively small area unable to proceed with their upstream migration to the spawning grounds until flood water lifted them over barriers. One cannot extrapolate on the basis of x number of specimens per y linear feet (or volume) of stream, especially during the spawning migration. Estimating the number of slackwater darters is hazardous. It is believed that their numbers in places other than Cypress Creek are dangerously low, and in Cypress Creek the population is no more than 3600.

Threats. The factor that limits the abundance and distribution of the slackwater darter is, of course, their habitat. It has undoubtedly waned in the past 200 years due to man's activities. The remaining refuges are subject to a number of threatening or potentially threatening phenomena:

1. Spreading urbanization is a potential threat to the physical integrity of habitat. Homebuilding, shopping centers, and industrial parks must be directed away from the essential habitat. Ditching to drain areas with shallow groundwater is a threat.

2. Degradation of surface and groundwater caused by the intrusion of toxins, pesticides, herbicides, fertilizers, as well as industrial and domestic wastes from sewage lines and septic tank seepage, and stockyard runoff are very real threats to the slackwater darter. Farming and cattle are the principal industries surrounding the darter's habitat. Since the breeding habitats are so limited, even a small chemical spill or biological pollutant could completely exterminate a breeding population.

3. Slackwater darter breeding habitats are "logical" sites for farm fish ponds. Much of the year the sites are too wet to plow, and as a pasture they abound in Juncus and Eleocharis, not the most desirable forage. Probably there are numerous extinct breeding sites inundated by farm ponds.

4. A beaver pond is definitely known to have destroyed a breeding site. The first breeding site discovered, on Bruton Branch of Burcham Creek, was inundated during 1977 by a beaver pond. Farmers will usually destroy beaver dams, but in this case the landowner apparently welcomed the impoundment as attested by duck blinds. Would breeding-ready darters return if the pond was drained? Must this species return, as salmon do, to their place of birth? These are questions that need answers, and if the latter answer is "yes," then this deme is extinct unless slackwater darters live much longer than we expect.

5. The USDA, Soil Conservation Service has had the Cypress Creek Watershed under study for a number of years relative to flood control. Several

studies were employed in the decision to revise the SCS's original plan. Reports of these studies are available from SCS, Auburn, Alabama. The final watershed plan was developed in concert with other Federal agencies including various offices in the Fish and Wildlife Service to insure that the results of the final flood control plan will not adversely affect the slackwater darter if certain guidelines are followed (see letter dated 2 November 1981 to Mr Ernest Todd, State Conservationist, SCS, Auburn, AL, from Walter O. Steiglitz, Regional Director, FWS; and letter dated 19 February 1982 to Col. Lee W. Tucker, District Engineer, Nashville District, Nashville, TN, from Gary L. Hickman, Area Manager, FWS, Jackson, MS).

PART II: RECOVERY

A. Recovery Objective

The objective of the plan is to delist the slackwater darter. This will require assurance that the fish's needs for survival are thoroughly understood and provided. Specifically, delisting must be preceeded by: 1) establishment and protection of one or more specific habitat areas (to be determined based on data from Tasks 1.1, 2.1, and 3) in at least three different tributaries to the Tennessee River System where the slackwater darter is known to occur with specific spawning areas to be protected by purchase or cooperative agreement; 2) data to indicate that the populations are stable or increasing in number; and 3) water quality and ecological data to indicate that the environment is suitable and stable or improving.

B. Step-down Outline

1 Assess current status of slackwater darter and its habitats.

- 1.1 Conduct winter and early spring census near and in known breeding habitats.
- 1.2 Determine physical requirements of the breeding and nonbreeding habitats, including water quality.

2 Conduct life history studies.

- 2.1 Study assembly, migration and migration routes.

2.2 Determine reproductive cycle of both sexes.

2.3 Study development and growth of young.

2.4 Determine demography.

2.5 Study competition and resource partitioning.

3 Locate breeding habitats for populations in Buffalo River, Flint River, Shoal Creek, and Swan Creek.

4 Protect slackwater darter essential habitat.

4.1 Continue coordination between the SCS and FWS to protect habitat in the Cypress Creek Watershed.

4.2 Develop and implement a cooperative management plan with the Natchez Trace Parkway Authority (NTPA).

4.3 Determine and implement most appropriate protection measures for significant habitat on private property.

4.4 Protect slackwater darter habitat through local land use planning.

C. Narrative

To delist the slackwater darter is a realistic goal, because it is feasible to gain the knowledge necessary to thoroughly understand the fish's needs for survival, and it probably will be possible to provide those needs.

1 Assess current status of slackwater darter and its habitats. It has been several years since most of the known habitats, both breeding and nonbreeding, have been reviewed. An updated inventory will be the first objective. Particularly, it must be determined if the known breeding sites are still extant. Once the habitat inventory is

brought up-to-date, a program of continuous monitoring will be initiated. Periodic inspections will be made of all breeding sites and selected stream sites. The monitoring will be done in concert with Federal and State agencies, local officials, landowners, and citizens as discussed in Step 4.

1.1 Conduct winter and early spring census near and in known breeding habitats. The monitoring program will include, over a 3-to-5 year period, winter and early spring censuses near and in selected breeding habitats in order to establish a data base. After developing these data, the population will be monitored at 3-year intervals to ensure a stable population. More frequent monitoring may be necessary in the event habitat disturbance occurs. The censuses will be conducted quarterly except during the breeding season when monthly sampling may be necessary. The censuses will be conducted without harming the fish populations. Numbers can be estimated fairly accurately by capture, mark, and recapture methods. Clipping a small piece of the dorsal or anal fin seems to work well. The method requires minimum handling and is probably less traumatic to the fish than injecting them with dye or attaching tags.

The censuses as described above would be of known concentration sites only and could not be used to obtain a total population estimate, but would be estimates of population sizes in given limited areas.

1.2 Determine physical requirements of the breeding and nonbreeding habitats, including water quality. During periodic visits to selected habitats, a program of base line data collecting relative to physical characteristics will be initiated. This one year study will include bi-weekly sampling over a ten week period during the breeding season at ten sites (8 breeding sites plus 2 similar sites lacking darters) and the adjacent streams. Data obtained at each site will include basic water chemistry parameters (pH, dissolved oxygen, total hardness, total dissolved solids, turbidity, temperature and specific conductivity). Upon receipt of the data, the need for additional studies will be determined.

As stated in the Introduction, the most important characteristic determining the distribution of nonbreeding slackwater darters is the physical nature of the stream. Even the stream microhabitat may be determined by tracking techniques (see Step 2.1). During this phase of the recovery plan, the variability of breeding habitats will be determined. At first the darters were known to breed only in pastures, but now it is known that slackwater darters breed in wooded areas as well, with the single unifying characteristic of the habitat being ground water.

Water quality standards of the breeding sites will be determined. Good water quality data is essential for the streams with known

populations. If slackwater darters return to their place of birth to spawn, what are the cues directing their migration? Is it some characteristic of the water by which they find their way? Perhaps an olfactory response as in salmon? Answers to these questions would be helpful to Step 2.1, and the answers will depend, in part, on good water quality data.

2 Conduct life history studies. Two sites will be selected, one on North Fork, a tributary to Main Cypress Creek; the other in the headwaters of Middle Cypress Creek. Observations and seine collections will be made monthly except during the reproductive season. During the beginning and end of reproductive activity, biweekly observations will be made. During the height of the reproductive season, observations will be made weekly. Omitted from the life history studies will be food studies except for those necessary for the study of competition and resource partitioning (2.5). Sacrificing large numbers of darters necessary for food habitat data on a monthly basis is not recommended. Darters are for the most part opportunistic sight feeders, there is no reason, on the basis of the study reported in the Introduction, to think that slackwater darters are an exception.

2.1 Study assembly, migration, and migration routes. Understanding the phenomena of assembly and migration is essential to understanding the needs of slackwater darters. Previous observations on North Fork indicate strongly that darters assemble in certain

places downstream of the breeding site and then make their final surge to the spawning area in unison. This sort of behavior permits the entire breeding deme to take advantage of a single high water event that will "lift" the darters into the spawning area. The question of how far the fish will migrate is important to the recovery. In other words, how large a geographic area can one breeding site serve? The answer to this question is necessary to help evaluate the importance of any single breeding site.

A study of the life history of slackwater darters, by the fact that they are migratory, has to be conducted a little differently from most darter studies. In addition to sampling predetermined places, this darter would also have to be followed and sampled wherever found. Lee and Ashton (1981) reported a successful technique of tracking whereby a small Cobalt 60 wire was inserted into the fish's flesh, and the fish's movement then monitored with a scintillation probe.

2.2 Determine reproductive cycle of both sexes. Data relative to the reproductive cycle of the slackwater darter have resulted from previous studies for the USDA Soil Conservation Service, but this information is not complete. It would be useful to conduct further studies leading specifically to the understanding of its reproductive cycle. A study of the reproductive cycle, using established methods for the study of darter biology, should be conducted at the same time as other studies in Step 2.

2.3 Study development and growth of young. There has been limited success in fertilizing eggs and rearing larvae in the laboratory (personal observation). The study of embryonic development should be a relatively simple matter in the laboratory. Larvae could be reared in the laboratory or taken at intervals from the field for the study of larval development. The scanty data indicate that the larvae leave the breeding habitat when they are about 17 mm T.L. Nothing is known about mortality of young in the breeding or nonbreeding habitats. Studies on growth of young can be accomplished simultaneously with other studies in Step 2.

2.4 Determine demography. Quantitative samples will be taken by repeatedly seining measured areas until no more specimens are collected. During part of the year, the measured areas cannot be predetermined due to the migratory habits of the darter. The specimens will be placed in holding tanks and returned to the water alive after measurements, sex determinations, etc., are made. Aging to year class will be done by counting annuli on a single scale removed from the dorsum, leaving the darter virtually unharmed. If the annuli method fails, length-frequency data will be used to attempt to age the darters. Specimens collected for this study will constitute part of the material for the census (Step 1.1).

2.5 Study competition and resource partitioning. Two species of fish, Etheostoma cf. squamiceps and Hemitremia flammea (flame chub) will enter the spawning grounds of the slackwater darter. As studies continue, other species may be encountered that compete with the slackwater darter. How competitive are they? How are the resources partitioned? If competition is intense, then the recovery plan may need to include methods to reduce competition.

3 Locate breeding habitats for populations in Buffalo River, Flint River, Shoal Creek, and Swan Creek. High priority should be given to a general survey for breeding sites in those streams where slackwater darters are known to occur. If and when located, they should be considered for the same protection recommended for the Cypress Creek populations.

4 Protect slackwater darter essential habitat. Once we understand the nature of the habitat and how it relates to the life requirements of the darter based on information obtained from Steps 1, 2, and 3, a plan for achieving the ultimate goal, i.e. delisting, may begin. In other words, once it is determined exactly what it is that should be protected and why, then it will be possible to proceed with the next step of the recovery plan.

4.1 Continue coordination between the SCS and FWS to protect habitat in the Cypress Creek Watershed. The SCS and the FWS should continue

coordination to insure that the plans of the SCS to build a number of floodwater retarding structures in the Cypress Creek Watershed will not seriously impact the slackwater darter. As the SCS work progresses, a monitoring effort will be maintained by on-site SCS or FWS inspectors. Contractors and subcontractors on the SCS project will be apprised of the seriousness of adhering strictly to the guidelines, and they will be required to follow the guidelines to the letter. If good faith prevails during the course of the SCS project, then the darter's habitats should endure.

The Lauderdale County office of SCS will be apprised of the slackwater darter's status, the habitat, etc., and this information can be considered by them in making their day-to-day recommendations regarding soil and water conservation so as not to adversely impact on the darter. Keep in mind that small floods in the headwater streams are necessary for migration of darters to the spawning ground. Onsite visits to critical areas will be made by SCS officials, the state fishery biologists and game wardens, FWS biologists, and the landowner for the purpose of pointing out critical areas that should not be disturbed. The landowner should be contacted and the importance of his land to the welfare of the darter should be explained.

4.2 Develop and implement a cooperative management plan with the Natchez Trace Parkway Authority (NTPA). The NTPA and the FWS will develop a cooperative management plan to insure the protection of slackwater darters and their habitat on property under NTPA jurisdiction (see map 3). Specifically, NTPA will be asked to protect the breeding site by: (1) identifying the site to all personnel likely to come in contact with it; (2) barring heavy machinery from the site during the breeding season, catagorically from January through May; (3) banning the use of pesticides, herbicides, or any other toxins, at all times; (4) posting the area with signs prohibiting any kind of access to the area; (5) allowing mowing machinery on the site only during dry periods when the ground water is fully receded; and (6) doing nothing to cause the disturbance of the adjacent stream.

4.3 Determine and implement most appropriate protection measures for significant habitat on private property. All of the other known breeding sites are on private land. This task will identify the appropriate means (either cooperative agreement, purchase of easements or land acquisition) to be used to provide the necessary level of protection to this habitat. This task should include (1) contacting the landowner at each breeding site and explaining the importance of his land to the welfare of the darter and (2) identifying the appropriate means for providing protection (i.e. cooperative agreement, purchase of easements or land acquisition).

Purchase or other appropriate means of protecting the Dodd sites 1 and 2 (Table 1) is particularly important as they are the best known and largest breeding sites. It must be kept in mind that if the breeding sites are not accessible to the darter, they are worthless. Plans to protect breeding sites must include assurance that adjacent streams will be protected. The order of priority for obtaining appropriate protection measures is the Dodd sites, Douglas Austin site and Miles site. The Dodd sites are supplied with water from springs as well as ground water.

It is not practical to expect to delist the slackwater darter with only one essential habitat area (breeding site and adjacent stream) under protection and at the same time leaving the others unattended. The areas are such that a single small accident could eliminate the entire breeding population. Therefore, it will be necessary to protect one or more specific habitat areas in at least three different tributaries to the Tennessee River System. Potential sites must be inventoried as standby sites for introductions if or when they may become necessary.

4.4 Protect slackwater darter habitat through local land use planning. Continued and constant cooperation between landowners, rural planners (and in some cases urban planners), county commissioners, TVA, FWS, NTPA, SCS, and state conservation departments, regarding land use is imperative.

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PART III: IMPLEMENTATION SCHEDULE

Priorities in column four of the following implementation schedule are assigned as follows:

1. Priority 1 - All actions that are absolutely essential to prevent extinction of the species.

2. Priority 2 - All actions necessary to maintain the species' current population status.

3. Priority 3 - All other actions necessary to provide for full recovery of the species.

List of Abbreviations

ADGF	Alabama Division of Game and Fish
THP	Tennessee Heritage Program
TWRA	Tennessee Wildlife Resources Agency
NTPA	Natchez Trace Parkway Authority
SCS	Soil Conservation Service

Part III Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency			Estimated Fiscal Year Costs			X $1,000
					FWS						
					Region	Program	Other	FY 1	FY 2	FY 3	Comments/Notes
R1	Conduct winter and early spring census near and in known breeding habitats.	1.1	3	See note	4	SE	Contract	4.2	4.6	5.0	Continue until recovery is accomplished.
R3	Determine physical habitat requirements including water quality.	1.2	3	1	4	SE	Contract	4.2			This is a pilot study. Additional funding may be necessary.
R8	Study assembly, migration and migration routes.	2.1	3	2	4	SE	Contract	4.2	4.6		
R7	Determine reproductive cycle of both sexes.	2.2	3	2	4	SE	Contract	6.9	7.6		
R14	Study development and growth of young.	2.3	3	1-2	4	SE	Contract	3.4	3.7		
R6	Determine demography.	2.4	3	1-2	4	SE	Contract	3.4	3.7		
R10	Study competition and resource partitioning.	2.5	3	1-2	4	SE	Contract	1.4	1.6		
R14	Locate breeding habitats for populations in Buffalo River, Flint River, Shoal Creek and Swan Creek.	3	2	1-2	4	SE	Contract	25.0	27.5		
A3	Continue coordination between the SCS and FWS to protect habitat in the Cypress Creek Watershed.	4.1	2	.5	4	SE	SCS ADGF TWRA THP	-	-	-	Accomplish as soon as data required from steps 1, 2 and 3 permit.
A3	Develop and implement a cooperative management plan with the Natchez Trace Parkway Authority.	4.2	2	.5	4	SE	NTPA	-	-	-	Same as above.

Part III Implementation Schedule

General Category	Plan Task	Task Number	Priority	Task Duration	Responsible Agency			Estimated Fiscal Year Costs			Comments/Notes
					FWS						
					Region	Program	Other	FY 1	FY 2	FY 3	
A3	Determine and implement most appropriate protection measures for significant habitat on private property.	4.3	2	1	4	SE	TWRA ADGF THP	-	-	-	Accomplish as soon as data required from steps 1, 2 and 3 permit.
A7	Protect slackwater darter habitat through local land use planning.	4.4	2	1	4	SE	TVA NTPA	-	-	-	Same as above. Continue until recovery is accomplished. Note: estimates are based on the assumption that steps 1 and 2 will be conducted simultaneously.

GENERAL CATEGORIES FOR IMPLEMENTATION SCHEDULES*

Information Gathering - I or R (research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

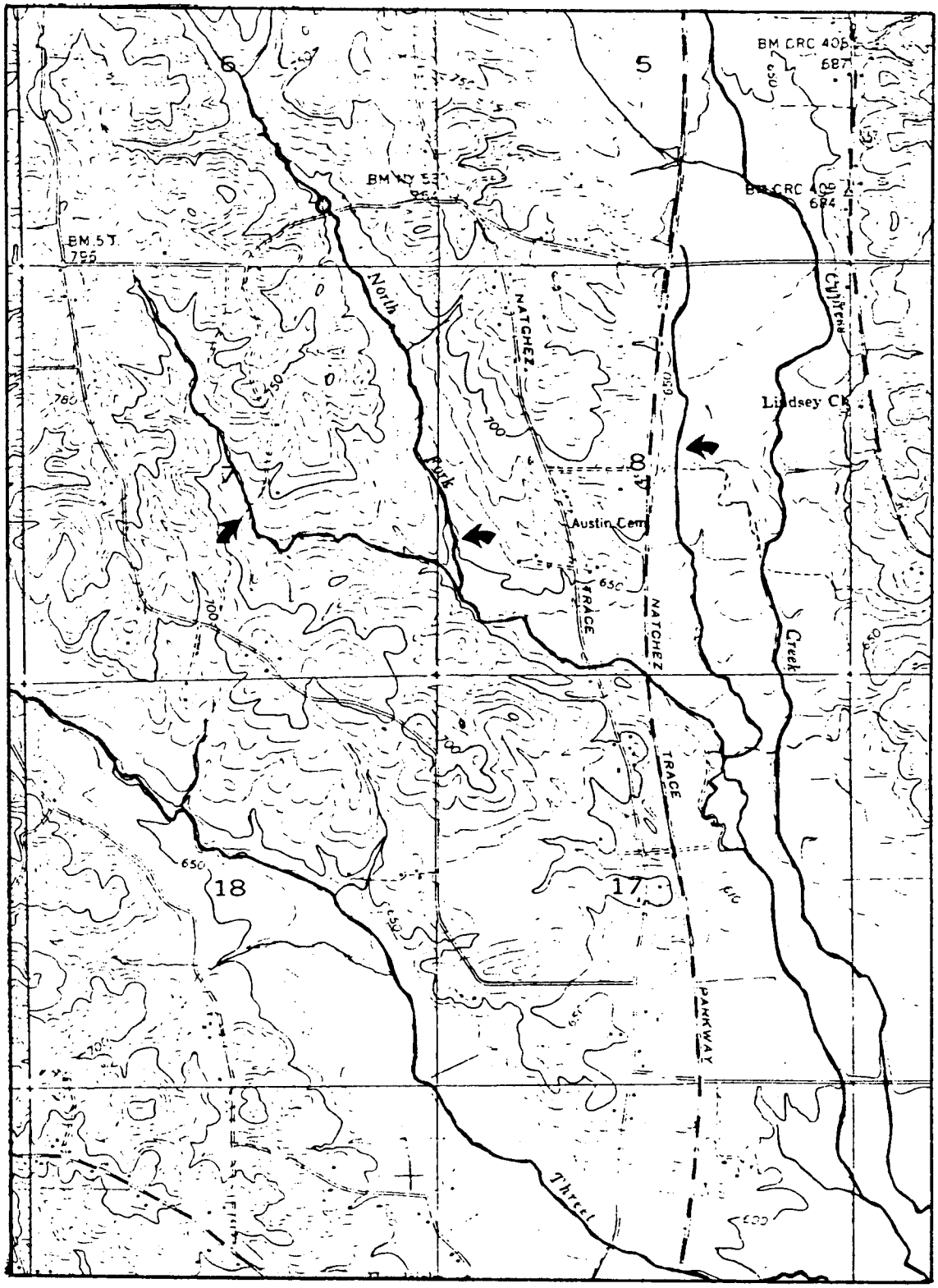
Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

* (Column 1) - Primarily for use by the U.S. Fish and Wildlife Service.

PART IV

APPENDIX A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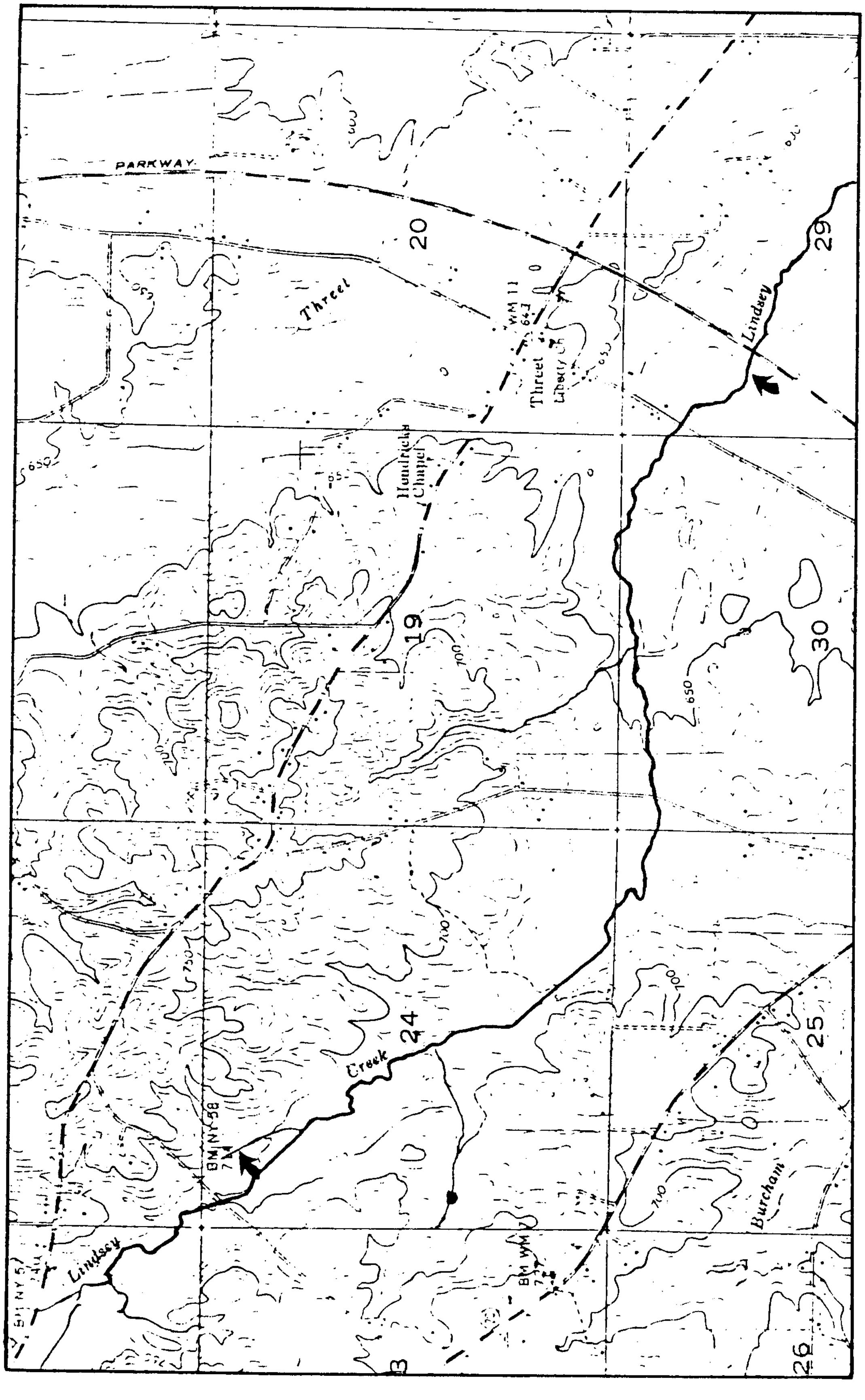
Map 1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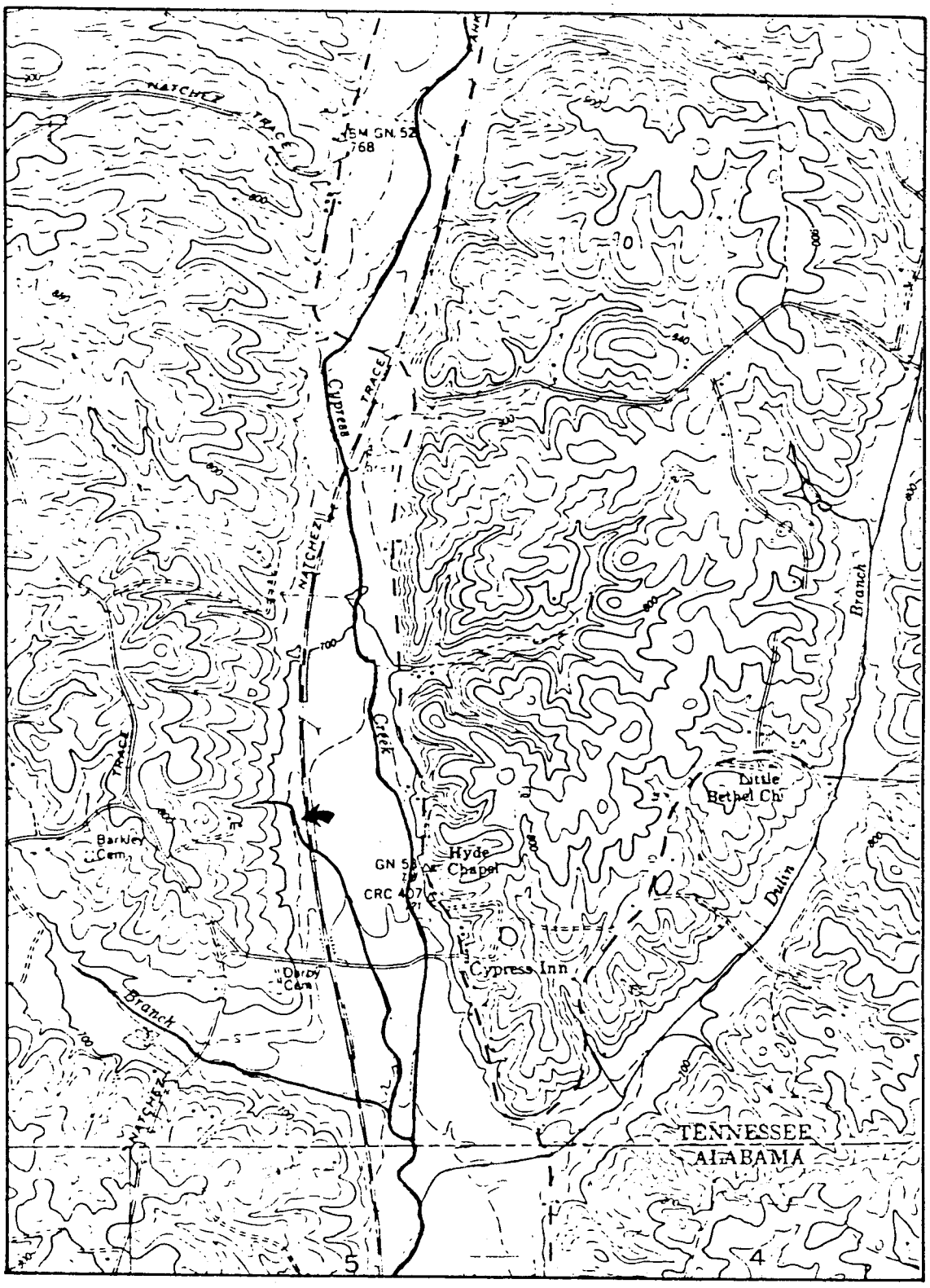
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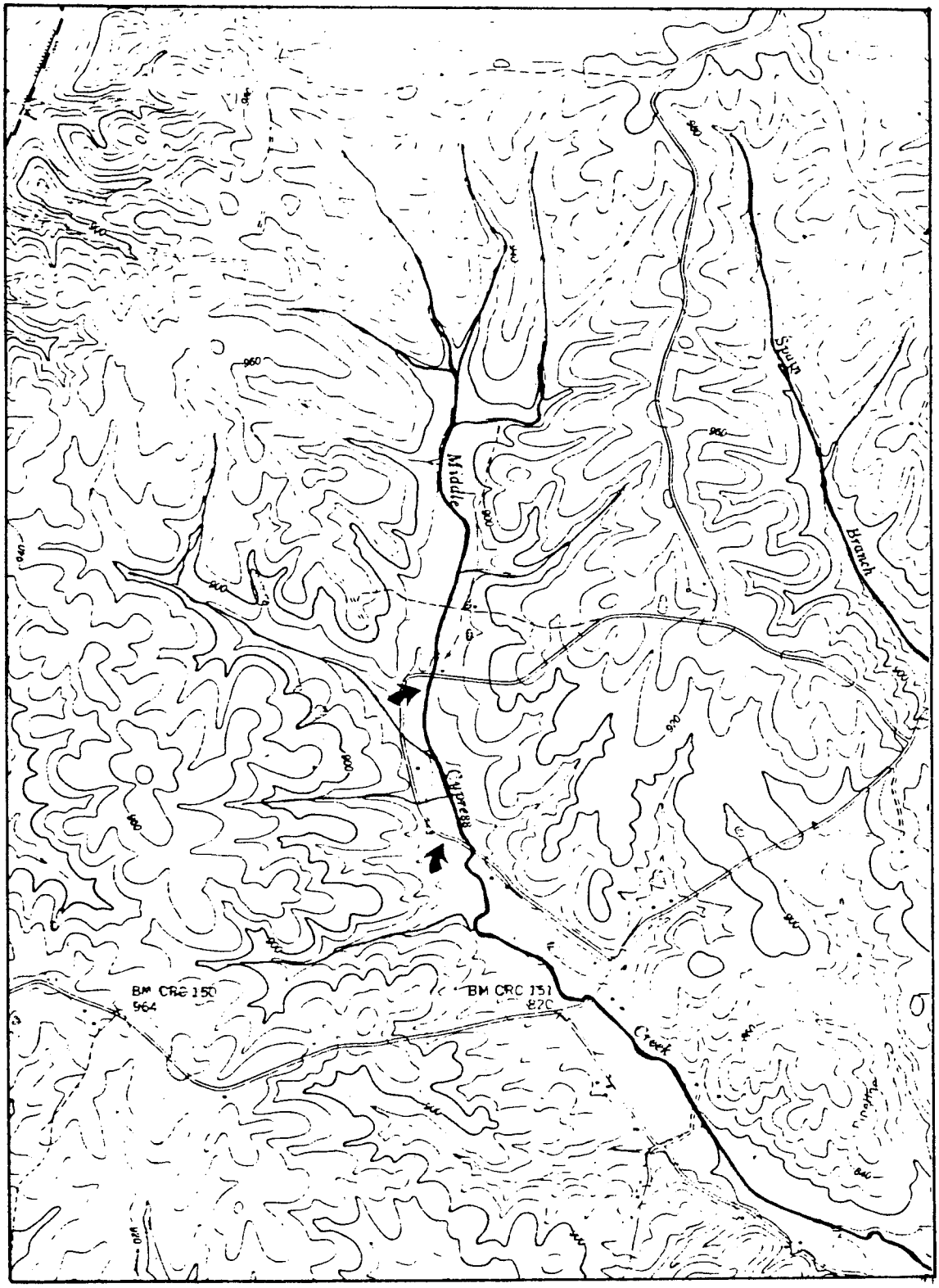
Map 3



Map 4

APPENDIX B

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